Mechanical Ventilation

Indications

- **Prolonged positive pressure ventilation**
- **Increased work of breathing**

Goals

- **Increase efficiency of breathing**
- **Increase oxygenation**
- **Improve ventilation/perfusion relationships**
- **Decrease work of breathing**

Types of Systems

- **Negative Pressure Ventilator**
  - **“Iron lung”**
  - **Allows long-term ventilation without artificial airway**
  - **Maintains normal intrathoracic hemodynamics**
  - **Uncomfortable, limits access to patient**

Types of Systems

- **Positive Pressure Ventilator**
  - **Uses pressures above atmospheric pressure to push air into lungs**
  - **Requires use of artificial airway**
  - **Types**
    - **Pressure cycled**
    - **Time cycled**
    - **Volume cycled**

Positive Pressure Ventilators

- **Pressure Cycled**
  - **Terminates inspiration at preset pressure**
  - **Small, portable, inexpensive**
  - **Ventilation volume can vary with changes in airway resistance, pulmonary compliance**
  - **Used for short-term support of patients with no pre-existing thoracic or pulmonary problems**

Positive Pressure Ventilators

- **Volume cycled**
  - **Most widely used system**
  - **Terminates inspiration at preset volume**
  - **Delivers volume at whatever pressure is required up to specified peak pressure**
  - **May produce dangerously high intrathoracic pressures**

Positive Pressure Ventilators

- **Time cycled**
  - **Terminates inspiration at preset time**
  - **Volume determined by**
    - **Length of inspiratory time**
    - **Pressure limit set**
    - **Patient airway resistance**
    - **Patient lung compliance**
  - **Common in neonatal units**

Volume-Cycled Ventilator Modes

- **Controlled Mechanical Ventilation**
  - **Patient does not participate in ventilations**
  - **Machine initiates inspiration, does work of breathing, controls tidal volume and rate**
  - **Useful in apneic or heavily sedated patients**
  - **Useful when inspiratory effort contraindicated (flail chest)**
  - **Patient must be incapable of initiating breaths**
  - **Rarely used**

Volume-Cycled Ventilator Modes

- **Assist Mode**
  - **Allows patient to control ventilator rate within limits**
  - **Inspiration begins when ventilator senses patients inspiratory effort**

Assist Mode

- **Assist/Control (A/C)**
  - **Patient triggers machine to deliver breaths but machine has preset backup rate**
  - **Patient initiates breath--machine delivers tidal volume**
  - **If patient does not breathe fast enough, machine takes over at preset rate**
  - **Tachypneic patients may hyperventilate dangerously**

Assist Mode

- **Intermittent Mandatory Ventilation (IMV)**
  - **Patient breathes on own**
  - **Machine delivers breaths at preset intervals**
  - **Patient determines tidal volume of spontaneous breaths**
  - **Used to “wean” patients from ventilators**
  - **Patients with weak respiratory muscles may tire from breathing against machine’s resistance**

Assist Mode

- **Synchronized Intermittent Mandatory Ventilation (SIMV)**
  - **Similar to IMV**
  - **Machine timed to delay ventilations until end of spontaneous patient breaths**
  - **Avoids over-distension of lungs**
  - **Decreases barotrauma risk**

Positive End Expiratory Pressure (PEEP)

- **Positive pressure in airway throughout expiration**
- **Holds alveoli open**
- **Improves ventilation/perfusion match**
- **Decreases FiO_2 needed to correct hypoxemia**
- **Useful in maintaining pulmonary function in non-cardiogenic pulmonary edema, especially ARDS**

Positive End Expiratory Pressure (PEEP)

DANGERS

- **High intrathoracic pressures can cause decreased venous return and decreased cardiac output**
- **May produce pulmonary barotrauma**
- **May worsen air-trapping in obstructive pulmonary disease**

Continuous Positive Airway Pressure (CPAP)

- **PEEP without preset ventilator rate or volume**
- **Physiologically similar to PEEP**
- **May be applied with or without use of a ventilator or artificial airway**
  - **Requires patient to be breathing spontaneously**
  - **Does not require a ventilator but can be performed with some ventilators**

High Frequency Ventilation (HFV)

- **Small volumes, high rates**
- **Allows gas exchange at low peak pressures**
- **Mechanism not completely understood**
- **Systems**
  - **High frequency positive pressure ventilation--60-120 breaths/min**
  - **High frequency jet ventilation--up to 400 breaths/min**
  - **High frequency oscillation--up to 3000 breaths/min**

High Frequency Ventilation (HFV)

- **Useful in managing:**
  - **Tracheobronchial or bronchopleural fistulas**
  - **Severe obstructive airway disease**
  - **Patients who develop barotrauma or decreased cardiac output with more conventional methods**
  - **Patients with head trauma who develop increased ICP with conventional methods**
  - **Patients under general anesthesia in whom ventilator movement would be undesirable**

Ventilator Settings

- **Tidal volume--10 to 15ml/kg (std = 12 ml/kg)**
- **Respiratory rate--initially 10 to 16/minute**
- **FiO_2--0.21 to 1.0 depending on disease process**
  - **100% causes oxygen toxicity and atelectasis in less than 24 hours**
  - **40% is safe indefinitely**
  - **PEEP can be added to stay below 40%**
  - **Goal is to achieve a PaO_2 >60**
- **I:E Ratio--1:2 is good starting point**
  - **Obstructive disease requires longer expirations**
  - **Restrictive disease requires longer inspirations**

Ventilator Settings

- **Ancillary adjustments**
  - **Inspiratory flow time**
  - **Temperature adjustments**
  - **Humidity**
  - **Trigger sensitivity**
  - **Peak airway pressure limits**
  - **Sighs**

Ventilator Complications

- **Mechanical malfunction**
  - **Keep all alarms activated at all times**
  - **BVM must always be available**
  - **If malfunction occurs, disconnect ventilator and ventilate manually**

Ventilator Complications

- **Airway malfunction**
  - **Suction patient as needed**
  - **Keep condensation build-up out of connecting tubes**
  - **Auscultate chest frequently**
  - **End tidal CO_2 monitoring**
    - **Maintain desired end-tidal CO_2**
    - **Assess tube placement**

Ventilator Complications

- **Pulmonary barotrauma**
  - **Avoid high-pressure settings for high-risk patients (COPD)**
  - **Monitor for pneumothorax**
  - **Anticipate need to decompress tension pneumothorax**

Ventilator Complications

- **Hemodynamic alterations**
  - **Decreased cardiac output, decreased venous return**
  - **Observe for:**
    - **Decreased BP**
    - **Restlessness, decreased LOC**
    - **Decreased urine output**
    - **Decreased peripheral pulses**
    - **Slow capillary refill**
    - **Pallor**
    - **Increasing Tachycardia**

Ventilator Complications

- **Renal malfunction**
- **Gastric hemorrhage**
- **Pulmonary atelectasis**
- **Infection**
- **Oxygen toxicity**
- **Loss of respiratory muscle tone**

Quick Guide to Setup

- Self check and/or Calibration as needed
- Check circuit and connections
- Set Mode: Usually “Assist/Control”
- Adjust “I” time: Usually 1 second
- Set tidal volume: 10-12 ml/kg is standard
  - May need to set “Flow” based on “I” time
- Set ventilatory rate: Adult 12-16/min

Quick Guide to Setup

- Set PEEP: std 5 cm H_20; max 20 cm H_20
  - Caution at 10 cm H_20 and greater
- Set “Assist/SIMV Sensitivity”: -2 cm H_20
- Set pressure alarms
- Assess patient to confirm ventilation function
  - Monitor vital signs
  - Pulse oximetry (waveform)
  - Capnography (waveform)